

**STATE OF CALIFORNIA
AIR RESOURCES BOARD**

**MEETING OF THE
RESEARCH SCREENING
COMMITTEE**

**May 30, 2014
9:00 a.m.**

**Air Resources Board
Research Division
Cal/EPA Building
1001 I Street
Sacramento, CA 95814
(916) 445-0753**

**State of California
AIR RESOURCES BOARD**

**Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Conference Room 510, 5th Floor
Sacramento, California 95814
(916) 445-0753**

**May 30, 2014
9:00 a.m.**

AGENDA

- | | |
|--|--------|
| I. Approval of Minutes of Previous Meeting: | iii-ix |
| March 28, 2014 meeting | |
| II. Discussion of New Research Projects: | |
| 1) "Association Between Long-Term Ultrafine Particulate Matter Exposure and Premature Death," University of California, Davis, \$849,115, Proposal No. 2775-279 | 1 |
| 2) "Behavioral and CNS Pathology Associated with Ultrafine Particle Exposure in an a-Syn Transgenic Mouse Model of Parkinson' Disease," University of California, Los Angeles, \$500,000, Proposal No. 2776-279 | 7 |
| 3) "Ozone in the Lower Atmosphere and its Contribution to High Ozone Concentrations at Ground-Level in the Southern San Joaquin Valley," University of California, Davis, \$300,021, Proposal No. 2777-279 | 11 |
| 4) "Characterization of PM2.5 Episodes in the San Joaquin Valley Based on Data Collected During the NASA DISCOVER-AQ Study in the Winter of 2013," \$200,000, University of California, Davis, Proposal No. 2778-279 | 17 |
| 5) "The Dynamics of Plug-in Electric Vehicles in the Secondary Market and their Implications for Vehicle Demand, Durability, and Emissions," University of California, Davis, \$300,000, Proposal No. 2779-279 | 23 |
| 6) "Potential to Build Current Natural Gas Infrastructure to Accommodate the Future Conversion to Near-Zero Transportation Technology," University of California, Davis, \$250,000, Proposal No. 2780-279 | 27 |
| 7) "The Development of Lifecycle Data for Hydrogen Fuel Production and Delivery," University of California, Davis, \$250,000, Proposal No. 2781-279 | 31 |

**State of California
AIR RESOURCES BOARD**

**Research Screening Committee Meeting
Cal/EPA Headquarters Building
1001 I Street
Conference Room 510
Sacramento, California 95814
(916) 445-0753**

**March 28, 2014
9:00 a.m.**

MINUTES

RSC Members in Attendance via teleconference

Harold Cota
Forman Williams
Steven Japar
Suzanne Paulson
Allen Vette
Philip Fine
Yifang Zhu
William Eisenstein

The Research Screening Committee (RSC or Committee) convened the meeting at 9:04 a.m. The minutes of the January 31, 2014 meeting were approved.

I. New Research Projects:

- 1) "Aerodynamic greenhouse gas (GHG) Emissions Reduction Assessment of Non-53-foot Trailers Pulled by Heavy-Duty Tractors," University of California, Riverside, \$500,000, Proposal No. 2770-278

Postponed.

- 2) "Evaluation of the Impacts of Emissions Averaging and Flexibility Programs for all Tier 4 Final Off-Road Diesel Engines," University of California, Riverside, \$300,000, Proposal No. 2774-278.

A Committee member asked how important it is to characterize these engines. Staff responded that since the Average Banking and Trading, and Transition Program for Equipment Manufacturers are federal programs administered at the national level, it is not known how individual states such as California are impacted and the impact could be significant. Staff from the Air Resources Board's (ARB) Mobile Source Control Division added that it is important to learn the emissions impacts of these emissions trading programs on the state's efforts to achieve

attainment with ambient air quality standards, and if there might be any issues with the current programs. Another Committee member commented that the contractor (UC Riverside) appeared to be well qualified and should be able to handle the project.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

- 3) "Evaluation of the Feasibility, Cost-effectiveness, and Necessity of Equipping Small Off Road Diesel Engines with Advanced PM and/or NO_x Aftertreatment," University of California, Riverside, \$800,000, Proposal No. 2769-278

The Committee was supportive of the proposal, but had three main comments:

- Include alternative technologies and fuels in the technical assessment of control technologies and compilation of various equipment sources in a typical air basin performed in Task 1a.
 - Staff agreed that the scope would be expanded to include evaluation of the potential feasibility and cost effectiveness of non-diesel alternative technologies and fuels including gasoline, liquefied petroleum gas, and electric. These evaluations would be for comparison purposes only, not as candidates for testing.
- Clarify the emission inventory sources in addition to the diesel off-road online reporting system equipment inventory sources that will be used to estimate the impact of controlling for certain engine classes or applications on the overall inventory in Task 1a. Clarify in Task 2 that University of California, Riverside will use the best inventory data available at the time needed to maintain the project schedule. This includes using several existing individual category-specific inventory models rather than waiting for the anticipated ARB consolidated inventory, if waiting would impact the project schedule.
 - Staff agreed that the proposal would be clarified to indicate that the best inventory data available at the time of project performance would be used.
- Add explanations or expand the methods used for market impact analysis such as including input from non-diesel manufacturers, to demonstrate how relying on data from the existing industry will not be simply protective of existing status quo.
 - Staff agreed that the proposal would be modified to address this issue.

Specific questions included the following:

- What specific types of engines would be the subject of this study?
 - Staff answered that off-road diesel engines include both mobile and stationary engines, generators, pumps, etc. Broad categories from the ARB emission inventory include airport ground support equipment, construction, above ground mining, industrial, and oil drilling.

- What is the definition of the term “load factor?”
 - Staff answered that load factor is the fraction of the rated power of the engine that is actually used. Current ARB off-road emission inventory annual activity is estimated from the number of engines * rated power * average fraction of rated power while in use * number of hours used per year. (This is in contrast to a fuel-based inventory approach.)

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

- 4) “Reducing Formaldehyde Emissions from Home Central Heating and Air Conditioning Filters,” Lawrence Berkeley National Laboratory,” \$350,000, Proposal No. 2771-278

The Committee asked if all study tests will be bench scale tests. Staff responded that this study would consist of bench-scale and full-scale tests.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

- 5) “Protocol Development for Vehicle Emission Toxicity Testing for Particulate Matter,” University of California, Davis, \$100,000, Proposal No. 2772-278

Staff informed the Committee that comments were received from the Office of Environmental Health Hazard Assessment and the review was fairly positive and that they felt the development of a standard operating procedure for toxicity testing would be very useful.

One Committee member:

- Commented that he felt that the information gained from this study would be valuable. He is unsure how broadly these recommendations would be accepted by the *in vitro* assay community. He suggested the possibility of having a non-diesel particulate matter (PM) related sample such as ash from Mount St. Helens.
- Inquired about the use of cell culture media for the single solvent sonication methodology. Staff informed him that was a suggestion made to the primary investigator to maintain consistency with previous studies and that there is a need for protein in sample for some assays to work.
- Expressed concern about the filters not being able to endure the harsh treatments proposed. Staff agreed with his concerns and will recommend that the principal investigator (PI) run his blank filters first before utilizing any diesel

PM containing filters.

- Had a question regarding the horizontal line next to “IL-8” in figure 3. Staff informed him that “HO-1, COX-2, IL-8, IL6 and CYP1A1” were all part of the same assay so those five rows can be considered a single experiment.
- Inquired about the selection of best methodology. Staff responded that will be a point of discussion with the PI, but in general, the decision will be based mostly on the ability of a sample to elicit a response when compared with the blank and on the lack of artifacts. The member agreed and made note of the fact that many solvents do have the ability to modify samples.
- Mentioned that the proposal was well written, had a logical framework, good approach, and was thorough. He inquired about submission of written comments and was informed by administrative staff that was not necessary.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

- 6) “Improving DNDC Modeling Capability to Quantify Mitigation Potential of Nitrous Oxide from California Agricultural Soils,” University of New Hampshire, \$199,797, Proposal No. 2773-278

The Committee asked if it is necessary to include Figure 1, the California ag land use map, which is not referenced in the proposal. Staff answered yes. The map shows where ag land GHG are located. The Committee also wanted a clarification on Task 4, whether the project will assess all three GHGs - CO₂, N₂O and CH₄, from California crop land. Staff confirmed that it is the case. The model will assess all three GHGs with the same set of inputs. No extra work would be involved.

Motion: Move to accept the proposal, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the proposal.

II. Draft Final Reports:

- 1) “Central Nervous System Effects of Ambient Particulate Matter: The Role of Oxidative Stress and Inflammation,” University of California, Irvine, \$309,141, Contract No. 08-306

The Committee requested that additional wording be added to the Executive Summary, Abstract, and Conclusions of the report, mentioning limitations of the study that prevented a more in-depth assessment of PM source contributions to the observed health impacts.

Motion: Move to accept the report, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the report.

- 2) "Air Movement as an Energy Efficient Means Toward Occupant Comfort," University of California, Berkeley, \$170,000, Contract No. 10-308

The Committee requested the contractor pull all of the critical findings into the Executive Summary.

Motion: Move to accept the report, subject to inclusion of revisions based on comments from staff and the Committee. William Eisenstein recused himself from the discussion of this item.

The Committee approved the report.

- 3) "Construction of a differential optical absorption spectrometer (DOAS) Instrument for Installation at the California Air Resources Board for the Low Level Measurement of Sulfur Dioxide to Investigate the Relation Between Sulfur Dioxide and Sulfate," University of California, Riverside, \$90,004, Contract No. 10-312

Written Comments from Committee with ARB Staff Replies:

- RSC Summary Book page 47, 3rd line: "for the range 290-320" --- *no units specified.*
 - Reply- The units are nanometers (nm).
- RSC Summary Book page 47, 3rd paragraph: --- *the diesel vehicle should be tested with and without a scrubber to check for the possible impact of a scrubber on SO₂* and, Draft final Report (DFR), various locations: *The potential use of a scrubber (see above) is mentioned in a number of places: page vi, bottom, page ix bottom of 4th tic mark; page 26 next to last paragraph; page 33 bottom of 3rd tic mark*
 - Reply- The following language recommending testing the effect of the NH₃ scrubber on SO₂ measurement will be included at the locations indicated: *"the diesel vehicle should be tested with and without a scrubber to check for the possible impact of a scrubber on SO₂"*
- DFR page vii, fifth tic mark from bottom: --- *why mention 230 nm if the instrument is going to be used at 215 nm? Confusion for the reader.*
 - Reply- The physical range of the spectrometer is optimized for the 200 to 230 nm range. To reduce interferences from NO and NH₃, the software selects a limited portion of this range, 206 to 214 nm, for spectral analysis. We will modify the paragraph to focus on the final range that was determined for the DOAS.
- DFR page vii, last tic mark: --- *the goal for detection limits was 10 ppb not the 20 ppb reported*
 - Reply- Agreed; the document will be revised to reflect the original target of

10 ppb. The original design called for a multi-pass White cell design with a path length of 10 to 20 meters. The maker of that cell went out of business and a redesign was required. The new design uses a single pass cell, with a 1 meter path length. The single pass cell offers the advantage of having all focusing and receiving optics outside of the cell, which allows easier cleaning, and the advantage of smaller cell volume, which allows faster response time. Despite higher throughput, and a ultraviolet (UV) spectral region with better signal to noise ratio in the shorter UV wavelengths, the shorter path length cell was not able to achieve 10 ppb, and we adjusted the working target to 20 ppb.

- DFR page ix, 2nd tic mark, bottom --- *the NO/NH₃ DOAS interference with SO₂*.
 - Reply- We will modify the text per this comment.
- DFR page 10, Sample Cell Measurements --- *7.5 slm ?? This also appears in the Summary Booklet*
 - Reply- The flow rate is 7.5 standard liters per minute (slpm). We will add the missing “p”. NOTE: Couldn’t find this in the Summary Booklet.
- DFR page 23, last paragraph – I don’t understand the first sentence --- ... *“permit masking of spectral regions influence by interference” ...*
 - Reply- The physical construction of the spectrometer limits the spectral range to about 200 to 230 nm. The spectral analysis software was revised to allow additional regions to be selected or excluded from the spectral analysis, in order to avoid regions of interference.
- DFR page 32, 2nd sentence – “to characterize and better understand” ...
 - Reply- We will make this correction.
- DFR page 32, 2nd tic mark – *how do beam expansion and optics focus minimize cell volume? I am guessing that they want to minimize the circumference of the beam??*
 - Reply-The beam expansion and focusing optics maximize light throughput and allow for a smaller cell. The PI will supply additional details and the report will be revised to include an explanation.
- DFR page 32, 2nd tic mark – “the sample cell was designed ...
 - Reply- We will make this correction.

Additional Comments Made During the Meeting with ARB Staff Replies:

- DFR pages 5 and 6 – Include the references for Figures 2-2 and 2-3.
 - Reply- We will include these.
- DFR page 6 – Include a clear, legible version of Figure 2-3.
 - Reply- This will be done.
- Include a discussion about the ClO concentrations in vehicle exhaust being too low to interfere with the SO₂ readings.

- Reply- This will be done.
- The device should have a manual for addressing operation, maintenance and troubleshooting of the DOAS.
 - Reply- This will be provided.

Motion: Move to accept the report, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the report.

- 4) "Improving Regional Biogenic Volatile Organic Compound Emission Estimates Using an Airborne PTRMS EDDY Flux Measurement System," University of California, Berkeley, \$400,000, Contract No. 09-339

The Committee requested the contractor pull all of the critical findings into the Executive Summary.

Motion: Move to accept the report, subject to inclusion of revisions based on comments from staff and the Committee.

The Committee approved the report.

III. Discussion of Other Business:

- 1) "Using Feedback from Commercial Buildings to Support Energy-Conserving Behavior," University of California, Berkeley, \$184,260, Contract No. 10-310

Staff informed the Committee that contract 10-310, "Using Feedback from Commercial Buildings to Support Energy-Conserving Behavior" with the University of California, Berkeley, needed to be terminated prematurely. The project was terminated due to technical difficulties in completing the tasks as well as misrepresentation of progress on the project from a post-doc that is no longer working on the project.

The meeting adjourned at 10:18 a.m.

DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: II.1

DATE: May 30, 2014

PROPOSAL NO.: 2775-279

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE: Association Between Long-Term Ultrafine Particulate Matter Exposure and Premature Death

CONTRACTOR: University of California, Davis, \$665,699

SUBCONTRACTORS: Cancer Prevention Institute of CA, \$89,125
University of Southern California, \$15,000
Bart Ostro, \$64,291
Thomas Kirchstetter, \$15,000

PRINCIPAL INVESTIGATOR: Michael J. Kleeman, Ph.D.

CONTRACT TYPE: Interagency Agreement

TOTAL AMOUNT: \$849,115

CONTRACT TERM: 36 Months

For further information, please contact Dr. Alvarado at (916) 445-4843.

I. SUMMARY

There is a large body of literature showing that fine particulate matter (PM_{2.5}) is associated with premature death, with the most persuasive evidence coming from long-term epidemiological studies. The epidemiological evidence for a similar relationship with ultrafine particles (UFP) is limited and inconclusive; the proposed study aims to help fill this research gap. The overall objective of the proposed study is to determine whether any feature of UFP's (number, surface area, or mass) is positively associated with premature death in California. The proposed study, which will combine statewide modeling of UFP distribution with monitoring data, will greatly strengthen the exposure analysis for UFPs relative to previous work that relied on central site monitors. The results of this study will provide ARB with a clearer understanding of the health

impacts associated with exposure to UFP, including health risk at ambient concentrations.

II. TECHNICAL SUMMARY

Objective

The objective of the proposed study is to perform a state-of-the-science exposure assessment for UFP's based on measurements and regional models and to determine whether UFPs are positively associated with premature death in California using an established epidemiological cohort.

Background

Although some UFP epidemiologic studies have been published, the results are inconsistent, and the studies lacked adequate exposure assessment at the regional level. Some studies have examined associations between short-term UFP exposure and mortality; however, these studies relied on central site monitors, which were not able to capture regional variation in UFP levels. There are no corresponding long-term UFP mortality studies, although published results suggest that UFP may be as toxic as, or possibly more toxic than, PM_{2.5}.

The results of the few epidemiologic studies of UFP are inconsistent, primarily because of the lack of an adequate exposure assessment at the regional level. To date, an adequate exposure assessment has not been conducted, largely because UFP has strong spatial gradients. This is clearly true for California, where ambient concentrations of UFP have not been adequately characterized by monitoring at the regional level. The proposed study will provide these regional UFP concentration estimates; moreover, modeled outputs will be validated through comparison with monitored levels. These validated UFP data then will be matched with an existing epidemiologic cohort. This integration of approaches will fill the critical need for a sound epidemiologic study on the health effects of long-term exposure to UFP.

Proposal Summary

The global objective described above can be divided into specific objectives to:

- 1) create a measurement dataset suitable for evaluating an ultrafine particle exposure

model; 2) perform ultrafine particle exposure model predictions and compare to measured ambient levels to evaluate performance; and 3) use the ultrafine particle exposure assessment in an epidemiological analysis.

Objective 1: Measure the UFP concentrations in three major California population centers and perform source apportionment using Positive Matrix Factorization (PMF) and Chemical Mass Balance (CMB).

Objective 2: Predict UFP concentrations across California with 4 km resolution over major population centers and 1 km resolution over sub-regions using regional Chemical Transport Models. Compare predictions to available measurements from various field projects, including those made under Objective 1.

Objective 3: Use standard epidemiological methods to identify associations between UFP concentrations and premature death in the California Teachers Study.

Six hypotheses will be tested in support of accomplishing the project objectives:

Hypothesis #1: A year of UFP measurements analyzed with PMF (3-day averages) and CMB (monthly averages) can identify unique sources of UFPs in the Bay Area of San Francisco, Fresno, and Los Angeles that are consistent with emissions and meteorological patterns in those regions.

Hypothesis #2: Regional Chemical Transport Models using standard emissions inventories combined with UFP source profiles can predict UFP concentrations and source distributions in major California population centers including the Bay Area, San Joaquin Valley, and Los Angeles for the years 1995-2015.

Hypothesis #3: Regions can be identified with sufficiently independent behavior for UFPs vs. other pollutants (PM_{2.5}, O₃, NO, NO₂, etc) to identify associations with premature death without confounding effects.

Hypothesis #4: UFP number (total and/or from different sources) is positively associated with premature death in California.

Hypothesis #5: UFP surface area (total and/or from different sources) is positively associated with premature death in California.

Hypothesis #6: UFP mass (total and/or from different sources) is positively associated with premature death in California.

Approach: A combination of measurements and model predictions for UFP concentrations (number, mass, chemical components, sources) will be used to estimate population exposure more accurately than those in previous epidemiological efforts, which relied on central site monitors. UFP samples will be collected in three California cities, and their composition will be analyzed. Statistical source apportionment calculations will be performed on these samples. UFP particle number and mass concentrations will be predicted using regional chemical transport models, and these modeled values will be compared with the collected samples, as well as other available UFP data that have been collected throughout California by Dr. Kleeman and others (for locations including numerous sites in the South Coast Air Basin and the San Joaquin Valley). Concentration fields generated by model predictions will be combined with geocoded addresses from the California Teachers Study to determine whether any feature of ultrafine particles is positively associated with premature mortality. Standard Cox proportional hazard models will be used to quantify all associations.

Expected Results: The UFP composition and source apportionment measurements generated for a year in the San Francisco Bay Area, Fresno, and Los Angeles will be the most comprehensive assessment of its kind in the world. The comparison of these measurements to regional model predictions will provide a rigorous test of the model capabilities over cities with very different size, sources, and meteorology that should lead to generalizable conclusions regarding model capabilities. The exposure assessment generated by the project activities will be useful to test against premature death as well as other health endpoints including stroke, asthma, low birth weight, etc. The overall assessment of UFP effects on human health using robust epidemiological methods will provide a first step towards elucidating the relationship between long-term exposure to UFP and premature mortality.

III. STAFF COMMENTS

Seven ARB Research Division (RD) staff provided detailed comments on this proposal, as did one reviewer from the Health Effects Institute. Additionally, several RD managers

and staff commented on the proposal. On the basis of the reviewers' comments, the principal investigator submitted two additional revisions of the proposal.

One of the main issues raised by reviewers was that the original proposal planned to perform modeling at a 4 km grid resolution size. There was concern that, due to the spatial and temporal variation in UFP levels, a finer grid resolution was necessary in order to provide adequate data for the health impact analysis. However, using a finer spatial resolution would increase the cost of the contract and increase the uncertainty of the UFP results as grid size decreased. Staff and the investigator agreed that the best resolution to this dilemma was to retain statewide modeling at a 4 km grid resolution, as initially proposed, but with the addition of 1 km nested grids in selected urban areas. Therefore, the researchers added nested 1 km modeling regions for three major urban areas, where a substantial proportion of California's population resides: Los Angeles, the San Francisco Bay Area, and Sacramento. Following reviewer recommendations, the researchers also shifted what would have been funding for a second epidemiological cohort to the modeling/monitoring effort. Reviewers were satisfied that a single cohort, the California Teachers Study, would be sufficient. The aforementioned changes were reflected in a subsequent revision of the proposal.

The reviewers also suggested that a technical advisory committee be assembled to consult with the researchers and ARB staff on the progress of this study. The researchers added a section to the proposal, stating that an advisory group would be formed, in consultation with ARB staff.

Reviewers requested clarification regarding several aspects of the study, such as what historical UFP monitoring data were already available, whether chemical speciation was necessary for this study, and whether current UFP levels were correlated with past levels. Therefore, in subsequent revisions, the researchers added additional sections to the proposal to address these concerns. Reviewers were satisfied that their questions were adequately addressed.

IV. STAFF RECOMMENDATION

Staff recommend the Research Screening Committee approve this proposal for a total amount not to exceed \$849,115, subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: II.2

DATE: May 30, 2014

PROPOSAL NO.: 2776-279

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE:	Behavioral and CNS Pathology Associated with Ultrafine Particle Exposure in an α -Syn Transgenic Mouse Model of Parkinson' Disease
CONTRACTOR:	University of California, Los Angeles, \$343,043
SUBCONTRACTOR:	University of California, Irvine, \$156,957
PRINCIPAL INVESTIGATOR:	Arthur K. Cho, Ph.D.
CONTRACT TYPE:	Interagency Agreement
TOTAL AMOUNT:	\$500,000
CONTRACT TERM:	36 Months

For further information, please contact Dr. Alvarado at (916) 445-4843.

I. SUMMARY

Emerging evidence suggests that environmental factors, including exposure to air pollutants such as particulate matter (PM), may play a role in neurodegenerative diseases (ND) such as Alzheimer's and Parkinson's disease. These conditions primarily affect the elderly. The cause of these disorders is not understood, and genetic factors alone seem insufficient to explain their prevalence. Ultrafine particulate matter (UFPM) is an important size fraction to examine because several reports in the literature have shown that these small particles are transported directly into the brain. The proposed study will investigate the effects of ambient UFPM exposure in a mouse model of Parkinson's disease, including innate immune responses in the brain, changes in brain pathology, and changes in cognition or behavior. The proposed study will help clarify the role of UFPM exposure in the progression of neurodegenerative disease, and will assist ARB in its mission of protecting public health, particularly in the elderly.

II. TECHNICAL SUMMARY

Objective

The objectives of this study are to determine: 1) whether long-term exposure to ultrafine particulate matter (UFPM) is associated with the development of neurodegenerative processes in a mouse model of Parkinson's disease; 2) whether UFPM exposure accelerates progression of innate immune responses in the brain; and 3) whether cognitive or behavioral deficits develop as a result of UFPM exposures.

Background

Numerous epidemiological and toxicological studies have demonstrated that exposure to ambient PM is associated with increased cardiopulmonary morbidity and mortality; much less is known about the effects of PM exposure on the brain. Recent research findings from human epidemiology, animal exposure, and *in vitro* studies suggest that air pollutant exposures may be associated with adverse central nervous system effects. Additionally, numerous animal models of neurodegenerative disease have been developed that demonstrate various pathological, immune, and cognitive or behavioral facets of ND. However, the role of ultrafine PM exposure on central nervous system pathology and cognition in these animal models has been largely unexplored. The proposed research will begin to address this gap.

Proposal Summary

This project will utilize a well characterized model of Parkinson's disease, a transgenic mouse that overexpresses human alpha-synuclein (α -Syn). α -Syn is a protein that is abundant in the brain; it aggregates to form the Lewy bodies that are characteristic of Parkinson's disease. Transgenic and wild type mice will be exposed to concentrated ambient ultrafine particulate matter (UFPM) for assessment of its potential to induce behavioral and brain deficits that are associated with the development and progression of Parkinson's Disease (PD) and related neurodegenerative diseases. Concurrently, matched cohorts will be exposed simultaneously to filtered, purified air as a control exposure. As the α -Syn transgenic mice age, they develop motor and cognitive deficits, together with other brain deficits (e.g., Lewy body-like inclusions, dopaminergic deficits) that are characteristic of progressive PD. α -Syn transgenic and their wild type littermates will be exposed to air containing concentrated ultrafine particles (UFPM) for

a 6 month term, with concurrent assessment of motor and cognitive behaviors at the midpoint and end of their exposures. The animals will then be sacrificed and the brains dissected for analysis of inflammatory (TNF α) and adaptive (HO-1) responses, expression levels of α -synuclein and phosphorylated α -synuclein, changes in cellular oxidation state, and brain neurochemistry. The extent of the behavioral and brain alterations will likely be a function of the chemical and biologic composition of the UFPM and the corresponding volatile organics exposure. Thus, mouse macrophage cell line-assays developed in the researchers' laboratories will be used to test the prooxidant, electrophilic, and proinflammatory effects of the UFPM samples and their associated volatile organic components. Collectively, the results will provide ARB with a quantitative assessment of UFPM exposure that models human exposures in Southern California and may endanger public health.

III. STAFF COMMENTS

ARB staff, along with one reviewer from the Office of Environmental Health Hazard Assessment (OEHHA), reviewed this proposal. Reviewers felt that the study was well designed, and the transgenic mouse chosen for this study seems appropriate and has been well characterized. Staff requested a few revisions to the proposal that was initially submitted. The researchers originally proposed an exposure duration of 240 hours, over a period of four months; however, reviewers requested a longer exposure. Therefore, the researchers agreed to extend the total exposure time to 480 hours, over a period of six months.

Additionally, staff requested additional details on several aspects of the study, such as the exposure site, role of each researcher on the specific tasks, the budget allocations, additional background information (e.g. about the *in vitro* tests), and a more complete description of the technical plan. The researchers addressed these issues in a subsequent revision.

The revised proposal, while addressing staff concerns, also called for an increase in the total budget, from \$492,919 to \$500,000.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$500,000, subject to inclusion of appropriate additions and revisions in response to the staff comments, and any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: II.3

DATE: May 30, 2014

PROPOSAL NO.: 2777-279

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE: Ozone in the Lower Atmosphere and its Contribution to High Ozone Concentrations at Ground-Level in the Southern San Joaquin Valley

CONTRACTOR: University of California, Davis, \$186,261

SUBCONTRACTOR: Scientific Aviation, Inc., \$113,750

PRINCIPAL INVESTIGATOR: Ian Faloona, Ph.D.

CONTRACT TYPE: Interagency Agreement

TOTAL AMOUNT: \$300,011

CONTRACT TERM: 27 Months

For further information, please contact Dr. Eileen McCauley at (916) 323-1534.

I. SUMMARY

The San Joaquin Valley (SJV) is one of two areas in the nation that have an "Extreme" nonattainment classification with respect to the National Ambient Air Quality Standard (NAAQS) for ozone. To attain the standard expeditiously, it is imperative to better understand how the various sources of ozone contribute to the high ozone concentrations. In addition, air quality models frequently have difficulty replicating the conditions associated with temperature inversions and the mixing processes that break them. This research proposes to extensively sample the lower 1500 meters of the atmosphere during four critical periods of the diurnal cycle using an instrumented research aircraft. Air quality and meteorological measurements will be made to characterize conditions aloft during five 3-day sampling campaigns when high ozone concentrations are forecast to occur in the southern SJV. By using two teams, each consisting of a pilot and flight scientist, the flights will collect nearly 10 hours of research data during each 24-hour period. The data to be collected and quality-assured include

horizontal winds, relative humidity, temperature, ozone, nitrogen dioxide, methane, and ethane. This data set, along with an ozone budget analysis, will provide observational constraints for evaluating the performance of ozone modeling for the State Implementation Plan (SIP) with respect to how well it characterizes critical atmospheric processes generating high ozone concentrations in the southern SJV.

II. TECHNICAL SUMMARY

Objective

The primary objective of this research is to make air quality and meteorological measurements aloft (in the lowest 1500 meters of the atmosphere) on days associated with forecasts of high ozone concentrations at ground-level sites. Of particular interest is the influence that the carryover of polluted air aloft on one day has on the succeeding day's ozone concentrations. This research is needed to better characterize the roles that various sources of ozone aloft play in causing exceedances of the NAAQS in the southern SJV.

Background

SJV is one of two areas nationally that have an "Extreme" nonattainment classification with respect to the NAAQS for ozone. To attain the standard, it is imperative to better understand how the various sources of ozone contribute to the high concentrations. During the evening and night, atmospheric processes (e.g., nocturnal temperature inversions, low-level jets of air flowing through the SJV) can cause the air aloft and the surface layer of air to have different physical and chemical characteristics. During the night, differences in emissions and atmospheric processes can cause significantly different pollutant concentrations in the two layers. While the surface layer of air is generally characterized by the routine air quality monitoring network, the isolated air a few tens to hundreds of meters above it is unknown or poorly characterized. In addition, air quality models frequently have difficulty replicating the conditions associated with temperature inversions and the mixing processes that break them. Air quality (e.g., O₃, NO₂) and meteorological (e.g., temperature, relative humidity) measurements are needed to characterize conditions aloft during episodes with high ozone concentrations at the surface in order to ascertain if the ozone modeling for the SIP is adequately characterizing these critical atmospheric processes.

Proposal Summary

University of California, Davis (UCD) personnel will collaborate with meteorologists (particularly at the Air Resources Board (ARB) and the San Joaquin Valley Air Pollution Control District (SJVAPCD)) to monitor the synoptic meteorological conditions throughout the summer with the goal of forecasting poor air quality for the southern SJV. With 24-48 hour notice of anticipated poor air quality, UCD plans to conduct measurements (for 3 consecutive days) during each deployment, approximately once every three weeks of the ozone season (June-September). To provide additional context for each deployment, UCD will also collect data during the aircraft transits between the home base (Davis) and the field base (Bakersfield).

Over three consecutive days, UCD will conduct 4 flights per day (see temporal sampling schematic in Figure 1), with each flight collecting data to estimate vertical, horizontal, and temporal gradients (necessary for estimation of the terms in the ozone budget equation). The flights will occur at various altitudes and locations between Fresno and the terminus of the Valley. Including equipment preparation, taxi, and transit times, each flight will last approximately 2.5 hours or 10 hours total during each sampling day. The four flights per day will be conducted at times of particular interest to understanding the diurnal dynamics of ozone in the southern SJV: in the early morning before photochemistry begins, in mid-morning when solar heating mixes the surface air with the air aloft, in the early afternoon when atmospheric mixing is deepest, in the early evening when the nocturnal boundary layer is forming, and in the late evening when the low-level jet of air being advected through the SJV is strongest. Because the sampling window potentially covers 4-5 months, the flights will be scheduled relative to solar time (i.e., sunrise, midday, sunset) to consistently characterize the aerometric conditions of interest.

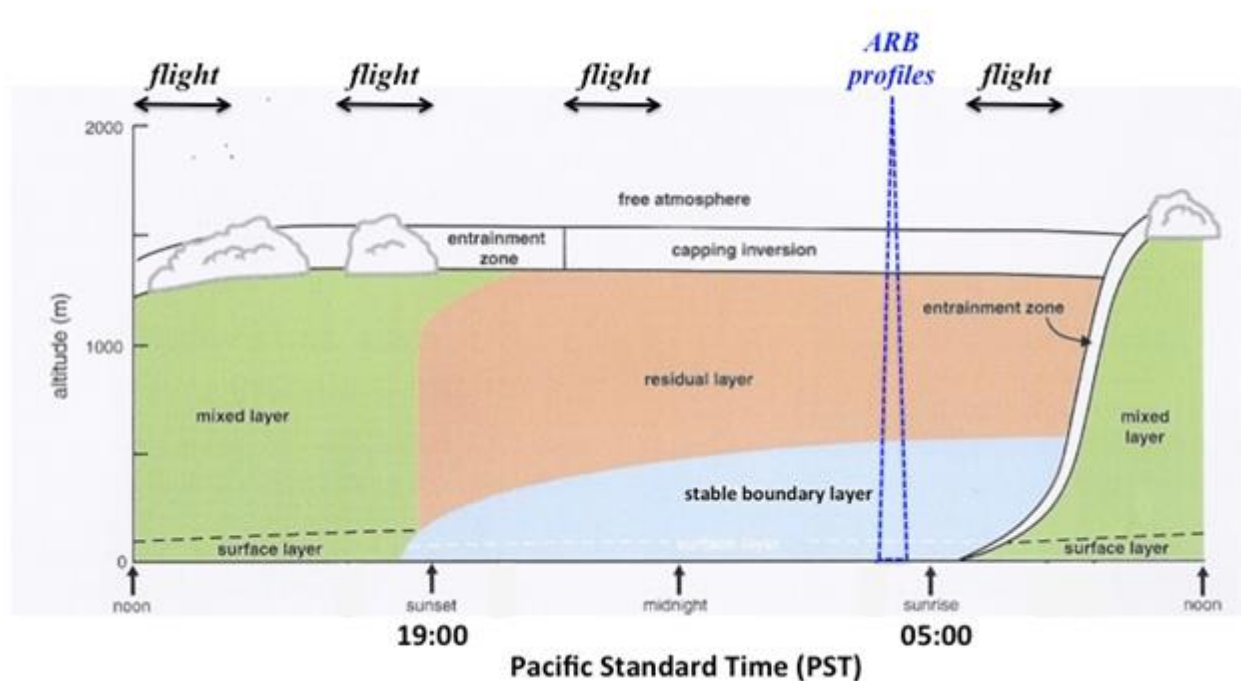


Figure 1. Timeline depiction of the layers of the lower atmosphere under investigation. The proposed 2-2.5 hour UCD sorties are shown along the top of the figure spanning the diurnal cycle. The daily early morning aircraft soundings over Fresno and Bakersfield (contracted by ARB's Meteorology Section) are also indicated. Times of sunrise and sunset are shown for August 1, and will be adjusted for the actual day of the year. Figure modified from Stull via Markowski & Richardson (2005).

Data to be collected and quality-assured include horizontal winds, relative humidity, temperature, ozone, nitrogen dioxide, methane (CH_4), and ethane (C_2H_6), all at 2-second resolution or better (equivalent to spatial resolution of ~125 m in the horizontal, 5 m in the vertical given typical cruising speeds and ascent/descent rates).

The proposed project will provide a new paradigm with which to improve air quality modeling efforts. For example, measurements will be made aloft during critical periods of the diurnal ozone cycle. In addition, by measuring the explicit terms of the ozone budget equation, this project will test specific model components (both transport and photochemistry) and quantify the contribution of O_3 aloft to the following day's maximum concentration at the surface. The measurements from this project will help to ensure that the ozone SIP modeling is adequately characterizing these critical atmospheric processes.

III. STAFF COMMENTS

The prospective Principal Investigator (PI) met with ARB staff in the Research, Air Quality Planning and Science Divisions to share insights and thoughts on how to best meet the project objectives. The PI then refined the pre-proposal to create the current proposal, which is being reviewed by the RSC and staff of the SJVAPCD and ARB. Any comments on this proposal that arrive after the deadline for inclusion in this RSC Agenda Book will be presented at the RSC meeting. The District has been very concerned for some time about the role that baseline O₃ concentrations (beyond the influence of local and regional emission controls) play in creating the District's severe O₃ air quality problem. The District has funded 2⁺ years of ridgetop monitoring at Chews Ridge in Monterey County to better document and characterize the transport of O₃ from Asia and the stratosphere into the SJV. In addition, it has contracted with UCD for instrumented aircraft flights to better document and characterizes the pollutants coming up the SJV from sources in the San Francisco Bay Area and the Sacramento Valley.

While the District's interest is primarily in characterizing advection of pollution into the Valley, ARB's primary interest for this project is characterizing the vertical mixing of O₃ and other pollutants in the layer of air aloft at night, which the routine monitoring network cannot characterize, into the boundary layer of air near the Earth's surface during the morning. The meeting to discuss this research concept convinced ARB staff that it is important to characterize the horizontal advection in order to more precisely characterize the impacts of vertical downmixing of O₃. The pre-proposal was refined to better address ARB's research needs and interests. For example, ozonesonde releases were dropped from the project in favor of a fifth deployment period.

However, a few additional refinements to the project plan by UCD are needed as well as significant additional support by ARB and District staff will be needed to make this field study as definitive as possible. The PI will work with an advisory group on flight plan details and forecasting for field operations. Some of the study details that will be developed or coordinated among the PI and the staffs of ARB & District during the planning phase include:

- 1) Developing the Flight Plan (e.g., specific flight times and paths) to ensure that the atmospheric processes are distinguished as well as possible. (UCD & ARB)

- 2) Developing the Quality Assurance and Quality Control (QA/QC) Plan (e.g., detailed description of the standard operating procedures as well as detailed QA and QC activities associated with making the measurements (e.g., pre-, mid-, and post-flight) and validating the data. (UCD & ARB)
- 3) Providing multi-day air quality forecasts during the summer of 2015. (District & ARB)
- 4) Adding temperature and humidity measurements to ARB's morning aircraft soundings at Fresno and Bakersfield. (ARB)
- 5) Coordinating the timing of ARB's morning aircraft soundings with this project's flight times and path to maximize the spatial and temporal coverage of air quality and meteorology measurements. (ARB & UCD)
- 6) Having UCD conduct contemporaneous collocated soundings on occasion with ARB's morning aircraft soundings to confirm measurement equivalence. (ARB & UCD)
- 7) Conducting a thru-the-probe audit of the project aircraft's instruments. (ARB & UCD)
- 8) Having ARB staff archive the routine air quality and meteorological data (both surface and aloft) during the project flight operations to ensure a full context for the project measurements. (ARB – RD & AQPSD)
- 9) Analyzing historical and study data (including the contemporaneous measurements by UCD at Chew's Ridge) and publishing the results/findings in one or more peer-reviewed journal articles. (ARB & UCD)

Staff is confident that the collaboration on this project will yield very useful results to ARB and the District.

IV. STAFF RECOMMENDATION

Staff recommends that the Research Screening Committee approve this proposal for a total amount not to exceed \$300,011, subject to inclusion of appropriate additions and revisions in response to the staff comments and any additional comments provided by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: II.4

DATE: May 30, 2014

PROPOSAL NO.: 2778-279

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE: Characterization of PM_{2.5} Episodes in the San Joaquin Valley Based on Data Collected During the NASA DISCOVER-AQ Study in the Winter of 2013

CONTRACTOR: University of California, Davis

PRINCIPAL INVESTIGATOR: Christopher D. Cappa, Ph.D.

CONTRACT TYPE: Interagency Agreement

TOTAL AMOUNT: \$200,000

CONTRACT TERM: 30 Months

For further information, please contact Dr. Eileen McCauley at (916) 323-1534.

I. SUMMARY

Although substantial progress has been made in improving the air quality in the San Joaquin Valley (SJV), wintertime PM_{2.5} air pollution in the Valley continues to be the worst in the State. Models used in air quality planning for the region are inconsistent in their ability to predict PM_{2.5} concentrations, which suggests a gap in understanding and in the overall conceptual model for PM_{2.5} formation in the SJV. National Aeronautics and Space Administration (NASA) chose the SJV for one of its Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) campaigns – a \$30 million NASA study to improve the ability of satellites to measure surface air quality. This measurement program created an extensive set of vertically resolved aircraft measurements of PM_{2.5} and important gaseous species for the SJV in January/February 2013. The aircraft measurements were complemented by a network of ground sites at which basic information on PM_{2.5} concentrations was collected and a ground “supersite” at ARB’s Fresno-Garland monitoring station which provided more detailed measurements of PM_{2.5} composition and properties. The objective of this project is to conduct advanced analysis of aircraft

and supersite measurements made during DISCOVER-AQ with the goal of improving the conceptual model of the origin, evolution, and spatial distribution of PM_{2.5} in the SJV. Comparison of the data analysis results with ARB's modeling will help identify strengths and weaknesses in ARB's conceptual model of PM episode formation in the SJV. The enhanced understanding of PM_{2.5} formation in the SJV will be of immediate value for developing air quality attainment strategies.

II. TECHNICAL SUMMARY

Objective

The proposed research has several objectives:

- 1) Investigate how the PM composition, gas-phase species, and meteorological fields vary with altitude and time of day over several sites in the SJV during DISCOVER-AQ. This analysis will provide insights into how extended PM episodes at the surface are connected to processes occurring aloft.
- 2) Provide a detailed characterization of physical and chemical properties of PM_{2.5} at the Fresno-Garland supersite during the DISCOVER-AQ study. The focus of this work will be on diurnal particle properties and in linking characteristics and differences in ground level behavior with the evolution of the vertical profile.
- 3) Improve and update the conceptual model for PM_{2.5} formation in the SJV in winter months. The investigators will work with ARB staff in refining the photochemical modeling of the study period, with an emphasis on the two PM episodes, based on results from the above analyses.

Background

The current numerical and conceptual models for PM formation in the SJV owe much of their development to the California Regional Particulate Air Quality Study (CRPAQS), which took place between December 1999 and February 2001. This study provided a broad suite of PM and gas-phase measurements from state-of-the-art (at the time) instruments located throughout the SJV. The measurements demonstrated that much of the PM_{2.5} in the SJV during winter is composed of ammonium nitrate (NH₄NO₃) or organic aerosol (OA). The spatial distribution indicated a more regional source for NH₄NO₃ and an urban source for OA. Measurements from a 90 m tower suggested that NH₄NO₃ formed aloft at night could explain some of the homogeneity of particulate

nitrate in the Valley; though it was also concluded that daytime surface formation of HNO_3 is important. Processes occurring above 90 meters could not be investigated, which limited the development of the current conceptual model for PM formation, especially in understanding the vertical distribution of pollutants in the SJV, how it evolves during the day, and impact on ground level PM.

The NASA DISCOVER-AQ campaign in the SJV during January/February 2013 was designed to help improve the ability of satellites to quantitatively measure surface air quality and produced an extensive set of surface and aloft (aircraft) ambient data. A surface supersite - Fresno-Garland - contained state-of-the-art real-time aerosol instruments, including a High-Resolution Aerosol Mass Spectrometer (HR-AMS), Particle-into-Liquid-Sampler (PILS) coupled with an ion chromatograph (for inorganic ions and water-soluble organic carbon), two scanning mobility particle sizers (SMPS), a cavity ringdown spectrometer, and a single particle soot photometer. Aloft measurements were taken from NASA's P3-B aircraft, which contained a suite of instrumentation for particle and gas-phase species. The P3-B flew throughout the SJV in a fixed pattern that was repeated three times each day, making low-altitude spirals over six ground sites. Atmospheric conditions during the campaign were optimal for the study of air quality: two episodes occurred in which $\text{PM}_{2.5}$ concentrations reached high levels and then dissipated. These buildups were regional in extent, and exceeded the United States Environmental Protection Agency $\text{PM}_{2.5}$ standard at many locations.

Proposal Summary

The main focus of the proposed research is on advanced analysis of the surface and airborne measurements of PM made during the DISCOVER-AQ campaign, with an emphasis on the two PM episodes. Using the unique set of air pollution and meteorological measurements from surface sites and the P3-B aircraft, the researchers will investigate the relative importance of different factors that contributed to the extended PM episodes in the SJV during the DISCOVER-AQ; these include primary emissions (e.g. motor vehicles, wood burning), physical processes (e.g. stagnation), and chemical processes (e.g. fog chemistry). The extent to which mixing of PM, or PM precursors, formed aloft influences surface PM concentrations will be explored using the temporal evolution of vertical $\text{PM}_{2.5}$ distributions. Measurements of particle

composition, or surrogates of composition, will be used to identify the sources of aloft PM. Ground-based measurements, especially HR-AMS measurements from the Fresno-Garland supersite, will be used to understand diurnal patterns of particle composition and to assess the extent to which aloft aerosol is related to surface PM_{2.5} properties and concentrations. These studies will be guided by five key hypotheses, which were developed through analysis of historical data and a preliminary examination of the DISCOVER-AQ data: H1) Particulate nitrate is formed primarily aloft at night, and transported downwards to the surface in the late morning, which leads to an increase in the surface concentration of nitrate and of PM_{2.5}; H2) Gas-phase precursors, such as HNO₃, are formed aloft at night and transported to the surface during the day, where they are mixed with air that has an overabundance of NH₃, which leads to rapid formation of particulate nitrate and increases in surface level PM_{2.5}; H3) Photochemical production of HNO₃ at the surface contributes to surface particulate concentrations during daytime; H4) Much of the organic aerosol is derived from primary emissions, but there is also formation of secondary organic aerosol that impacts ground level concentrations; H5) One reason for the sometimes poor model/measurement agreement in terms of surface PM_{2.5} concentrations is insufficient model resolution in the vertical. Based on these results, the researchers will update, refine and test the conceptual and numerical models for PM_{2.5} formation in the SJV.

III. STAFF COMMENTS

ARB staff from the Air Quality Planning and Science and Research Divisions reviewed this proposal and has helped strengthen some tasks to better address ARB's modeling efforts. The project should significantly improve our understanding of the composition, sources and processing of aerosols in the SJV and provide a better model for PM_{2.5} formation in the SJV. The proposal is well written and staff's only request is the addition of a list of explicit deliverables.

Dr. Chris Cappa has an extensive background in aerosol measurements and has been co-investigator of several ARB projects, including "Improving Chemical Mechanisms for Ozone and Secondary Organic Carbon: SAPRC14." Staff is confident that Dr. Cappa's work would provide new and important information about primary and secondary PM_{2.5} sources and processing in the SJV, which is critically needed in the development of

optimal air pollution mitigation strategies. Additionally, this project would represent a significant leveraging of resources and datasets: the extensive DISCOVER-AQ dataset in the SJV was acquired under NASA sponsorship.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$200,000 subject to any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: II.5

DATE: May 30, 2014

PROPOSAL NO.: 2779-279

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE: The Dynamics of Plug-in Electric Vehicles in the Secondary Market and Their Implications for Vehicle Demand, Durability, and Emissions

CONTRACTOR: University of California, Davis

PRINCIPAL INVESTIGATORS: Gil Tal, Ph.D.
David Rapson, Ph.D.
Thomas Turrentine, Ph.D.

CONTRACT TYPE: Interagency Agreement

TOTAL AMOUNT: \$300,000

CONTRACT TERM: 30 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

Plug-in electric vehicles are expected to play a major role in achieving the reductions of greenhouse gas emissions and criteria pollutants required by California's Low Emission Vehicle (LEV III) program, the California Global Warming Solutions Act of 2006 (AB 32), and increasingly stringent National Ambient Air Quality Standards. This project will characterize the dynamics of the secondary market for plug-in electric vehicles (PEVs) in California to improve estimates of the emission benefits of PEVs and projections of the overall emissions from the light-duty fleet. Researchers will employ surveys, interviews, and an economic model to evaluate the impact of factors such as battery life, energy prices, infrastructure availability, attributes and prices of new vehicle offerings, and economic conditions, on the demand and prices of used PEVs and on their usage. Results will inform future decisions by ARB policymakers on the treatment of PEVs by various ARB programs, such as incentives, durability requirements, or vehicle crediting.

II. TECHNICAL SUMMARY

Objective

This project will characterize the dynamics of PEVs in the secondary market to understand the longer term emission implications from an increasing market share. The results of this study will be useful to refine long term projections of emissions benefits from PEVs, and to inform future decisions by ARB policymakers, beginning in 2016, on the treatment of these vehicles by various ARB programs, such as incentives, durability requirements, or vehicle crediting.

Background

While manufacturer compliance with ARB's Zero Emission Vehicle (ZEV) program is based on new vehicles sales, the expected emission benefits will require that these vehicles, including PEVs, remain in the fleet past the first owner. PEV sales over the past three years are approaching a total of 70,000 in California and many early consumers have been opting to lease rather than purchase these vehicles – either in response to competitive lease offers, uncertainty about current technology, and/or expectations for future developments – which will accelerate the development of a large secondary market of PEVs. This market will begin developing in late 2013, and initiating new research in these early stages will allow for comprehensive monitoring of its development process.

Proposal Summary

This study will estimate the potential longer-term emissions benefits of PEVs by examining the early stages of the market for used PEVs. The investigators will conduct both qualitatively rich and quantitatively rigorous analyses of vehicle and market data on PEVs. Data sources will include comprehensive vehicle ownership/lessee databases, dealership inventory and sales data, commercially-sourced market and pricing data, and surveys and interviews of used PEV buyers.

Data analysis will include evaluation of factors such as battery life, energy prices, infrastructure availability, attributes and prices of new vehicle offerings, and economic conditions, on the demand and prices of used PEVs and on their usage. This research project will employ an econometric model to examine the Statewide market for used

PEVs, including the factors that are related to price variation of used PEVs (e.g., HOV sticker, State and federal incentives, mileage, battery life, etc.), the demand for used PEVs (including regional variations within California and out-of-State, and the role of charging infrastructure), and the relationship between the primary and secondary PEV markets. This project will also employ surveys and interviews to characterize used PEV buyers (socioeconomic and demographic characteristics, household fleets, etc.), their purchase motivations (value placed on vehicle attributes, incentives, charging access, etc.), and how they are using and charging their vehicles. The analysis will also evaluate whether the secondary market is expanding access to advanced clean cars, such as PEVs, to a wider array of consumers than the new PEV market. Additionally, the study will explore the variety of reasons that PEVs are entering the used market in order to gauge consumer acceptance of this class of technology.

III. STAFF COMMENTS

ARB staff (Research and Emissions Compliance, Automotive Regulation, and Science (ECARS) Divisions) reviewed and provided comments on this proposal. ECARS staff feels that the results of this research project will be useful for the Midterm Review of the Advanced Clean Cars program to address concerns raised by auto manufacturers at the initial rulemaking regarding the demand for used PEVs, and to inform decisions about the future of incentive programs for PEV purchases and regulatory requirements for battery warranties.

The research team is highly qualified to conduct this project, with multiple Ph.D.'s and expertise spanning engineering, economics, and other social sciences. The team has extensive experience studying vehicle purchasing behavior and alternative fuel vehicles through surveys, interviews, and economic modeling, which they will apply to studying the secondary market for plug-in vehicles in this project.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$300,000, subject to inclusion of any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: II.6

DATE: May 30, 2014

PROPOSAL NO.: 2780-279

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE: Potential to Build Current Natural Gas Infrastructure to Accommodate the Future Conversion to Near-Zero Transportation Technology

CONTRACTOR: University of California, Davis, \$187,500

PRINCIPAL INVESTIGATOR: Amy Jaffe

CONTRACT TYPE: Interagency Agreement

TOTAL AMOUNT: \$250,000

CONTRACT TERM: 18 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

Research is needed to determine what natural gas infrastructure would be economically and technologically ideal for both natural gas in the near-term, and alternative fuels in the long term. The original design of the Low Carbon Fuels Standard (LCFS) provides time for the development of advanced, near-zero technologies. However, having infrastructure already in place to deliver alternative fuels to fleets, once more alternative fuels are already in place, will ease the future transition to zero or near-zero transportation technology (e.g. biofuels, electric and fuel cell technology). This proposed project will complement ARB's on-going work by exploring how the near-term development of natural gas infrastructure, in the heavy-duty transportation sector, can be implemented to include technology that can best facilitate the long-term conversion to near-zero technology. Alternative fuels that will be considered in this analysis include hydrogen, renewable diesel, renewable natural gas, and dimethyl ether (DME). Results will provide essential data that will inform future refinements to the State's LCFS program and other climate change and air quality initiatives.

II. TECHNICAL SUMMARY

Objective

This project will investigate how the near-term development of natural gas infrastructure can be implemented to include technology that can best facilitate the long-term conversion to near-zero technology. The role of policies and/or incentives that encourage the use of infrastructure that can accommodate both natural gas and alternative fuels will be explored.

Background

The abundance of natural gas, coupled with its low price and multiple applications across all energy use sectors, means that it will continue to play an important role in the United States energy system in the near future. Natural gas is often touted as a ‘bridge’ to low carbon fuels in the heavy duty transportation sector, and the number of natural gas-fueled medium and heavy-duty fleets is growing rapidly. Research is needed to determine whether the natural gas infrastructure that is being deployed to meet this rising demand for fossil-based natural gas fuels could economically and technologically serve as a jump-off point to facilitate a shift to more near zero alternative fuels in the long term. The original design of the LCFS provides time for the development of advanced, near-zero technologies. However, having infrastructure already in place to deliver alternative fuels to fleets, once more alternative fuels are already in place, will ease the costs and difficulties for the future transition to zero or near-zero transportation technology. ARB’s current research is addressing the development of the commercial-scale production of alternative fuels in California. This proposed project will complement ARB’s on-going work by exploring optimum paths for developing distribution and fueling infrastructure in the near-term that will accommodate alternative, low carbon fuels once those are being produced at the commercial scale.

Proposal Summary

This investigation will focus on infrastructure for medium and heavy-duty fleets with a scope that includes potential synergies with light duty infrastructure. Alternative fuels that will be considered in this analysis include hydrogen, renewable diesel, renewable natural gas, and dimethyl ether (DME). This analysis will also identify the role of policies and incentives that encourage the use and construction of infrastructure that can

accommodate both natural gas and alternative fuels. The project's scope includes a literature review to compile costs and technological and environmental limitations for fuel infrastructure (pipelines, storage tanks, filling stations, delivery trucks, etc.) to accommodate both natural gas and alternative fuels, for all levels of medium and heavy-duty fleet operation (private small fleet operators to large commercial distribution). The researchers will also gather information on potential synergies with light duty infrastructure. The researchers will use the information gathered in the literature review to define the technological and/or economic barriers to the availability of multi-use infrastructure and develop potential strategies that could be implemented by State agencies to encourage the use of such infrastructure in the near-term. The researchers will then explore the role of policies and incentives that encourage the use of infrastructure that can accommodate both natural gas and alternative fuels.

ARB's 2011 LCFS Program Review Report indicates that a major barrier to expanded alternative fuel use includes the availability of appropriate fuel infrastructure. Results will provide strategies to maximize the current market penetration of fuel infrastructure that can accommodate alternative fuels in the long-term, which will ease the transition to a zero or near-zero transportation sector in the future. If this research leads to the development of a seamless transition to low-carbon fuels, it will smooth implementation of the LCFS and benefit California consumers.

III. STAFF COMMENTS

The ARB research program aims to collaborate with institutions engaged in similar research activities and to leverage funding whenever possible. ARB is continuing this trend in the 2014-15 fiscal year by committing \$1,000,000 over the next two years to support the creation of the National Center for Sustainable Transportation (NCST) at the University of California, Davis (UCD). This proposed project will partially fulfil the \$1,000,000 commitment and will leverage the \$5.6 million award the NCST received from the U.S. Department of Transportation and \$4.6 million from state, regional and local agencies, such as Caltrans and the South Coast Air Quality Management District.

The 12-person review team for this project included staff from the Stationary Source Division, the Air Quality, Planning and Science Division, the Mobile Source Control

Division, and the Research Division at ARB. Staff wrote the original statement of work (SOW) based on the research needed to support the implementation of several ARB initiatives, including the Vision Project, LCFS development and the technology assessment for the Sustainable Freight Strategy. The director of the NCST forwarded this SOW to researchers involved with the Center. Amy Jaffe's team at UCD responded to the SOW with a thorough draft proposal. After addressing minor comments from the ARB review team (that were only related to the budget and task logistics), Amy Jaffe submitted the final proposal.

UCD has assembled an impressive group of experts for this project. Mrs. Amy Jaffe will serve as the principal investigator and will oversee UCD's portion of the project. Mrs. Jaffe is a widely published, leading expert on global energy policy and energy and sustainability. The team at UCD has extensive experience in investigating natural gas infrastructure, vehicles and life cycle analyses. The UCD team will lead the policy analysis and compilation of the final report. A subcontract was established with UC Riverside (UCR) to assist with the literature review and assessment of barriers to the installation of infrastructure that can support advanced fuels. The subcontract with the UCR team was essential due to their expertise in the heavy duty sector.

IV. STAFF RECOMMENDATION

Staff recommends that the Research Screening Committee approve this proposal for a total amount not to exceed \$250,000, subject to inclusion of any changes and additions specified by the Committee.

DISCUSSION OF A NEW RESEARCH PROJECT

ITEM NO.: II.7

DATE: May 30, 2014

PROPOSAL NO.: 2781-279

STAFF EVALUATION OF A RESEARCH PROPOSAL

TITLE: The Development of Lifecycle Data for Hydrogen Fuel Production and Delivery

CONTRACTOR: University of California, Davis, \$125,000

SUBCONTRACTOR: University of California, Riverside, \$125,000

PRINCIPAL INVESTIGATOR: Marshall Miller, Ph.D.

CONTRACT TYPE: Interagency Agreement

TOTAL AMOUNT: \$250,000

CONTRACT TERM: 24 Months

For further information, please contact Annmarie Rodgers at (916) 323-1517.

I. SUMMARY

The Low Carbon Fuel Standard (LCFS) currently includes several pathways for hydrogen fuels. However, more pathways are needed, especially for the production of renewable hydrogen and pathways that include novel technology. This project will analyze lifecycle GHG emissions for the production and delivery of hydrogen to light and heavy duty vehicles in California for processes not currently included in published LCFS pathways. The results from this project's literature review and life cycle analysis will allow ARB staff to develop new hydrogen pathways for the LCFS regulation. While hydrogen usage in the transportation sector can help reduce GHG emissions, the potentially low initial market demand may result in a barrier to commercialization. This project will therefore identify additional hydrogen markets outside of the transportation sector that could be served by hydrogen facilities. If there are barriers to growth in these additional markets, the project will identify strategies and policies to overcome these barriers. These additional markets and strategies to overcome low hydrogen demand can help fuel companies to meet the target goals in the LCFS regulation.

II. TECHNICAL SUMMARY

Objective

The objective of this project is to develop lifecycle analyses of criteria pollutant and GHG emissions for the production and delivery of hydrogen transportation fuel in California. The project will also identify additional hydrogen markets outside of the transportation sector in order to ensure the viability of the hydrogen market in the near-term.

Background

The LCFS regulation is designed to reduce lifecycle GHG emissions in the transportation sector. The regulation assesses a carbon intensity score for the full lifecycle of each fuel pathway. The regulation lowers overall GHG emissions by requiring each fuel provider to meet the annual carbon intensity target for a given year. As this carbon intensity target decreases over time, the GHG emissions from the transportation sector will also decrease with time. ARB has performed a lifecycle assessment of many transportation fuel pathways and assigned carbon intensity scores to these pathways, but additional pathways exist that have not yet been analyzed and do not yet have such scores. For example, there are currently no LCFS pathways for renewable hydrogen, although the technology for its production currently exists in California. While ARB staff working on the LCFS need from lifecycle data on new pathways that include technology that is currently available, ARB staff working on the Vision Project, will benefit from lifecycle data on potential pathways using technology that will become available in the 10 and 20 year timeframe.

Proposal Summary

This project will analyze lifecycle greenhouse gas and criteria pollutant emissions for the production and delivery of hydrogen to light and heavy duty vehicles in California for processes not currently included in published LCFS pathways. This analysis will enable ARB staff to develop new hydrogen pathways for the LCFS regulation. This study will review published literature to assess the fuels, infrastructure, and vehicle technology

that can produce and utilize hydrogen in order to determine the most effective combinations not currently in the published LCFS to reduce greenhouse gas and criteria pollutants. The focus will be technologies and fuels related to renewable hydrogen. The production technologies will include thermal, electrolytic and photolytic processes. The literature review will produce a set of hydrogen pathways for further analysis. The study will examine the potential to use the current natural gas infrastructure for hydrogen distribution. The study will analyze: the potential to leverage the current natural gas infrastructure to transport hydrogen by examining the percentage of hydrogen in the gas mixture that natural gas pipelines could support; the effect on natural gas quality from any potential contaminants in the hydrogen; and issues related to separating out the hydrogen from the natural gas at the destination. A lifecycle analysis (LCA) will be performed to determine the hydrogen pathways with the lowest GHG and criteria pollutant emissions. This analysis will include production, distribution, and storage of renewable hydrogen or hydrogen produced with technologies or fuels not currently in the LCFS. The study will assess which hydrogen production, distribution, and storage technologies will be available in the 5-year, 10-year, and 20-year timeframes. An economic assessment will be performed to estimate the hydrogen costs for each potential pathway. The economic assessment will be combined with the LCA emissions reductions estimates to determine the most cost-effective pathways for the production, distribution, and storage of hydrogen fuel. The market demand for hydrogen as a transportation fuel could be relatively low during the initial usage period. The potential low demand could act as a barrier to commercialization for hydrogen fuel. The study will identify potential non-transportation markets that could be served by hydrogen facilities during this early commercialization period. The study will also determine any potential barriers to growth in these non-transportation markets and attempt to find strategies or policies to overcome these barriers.

III. STAFF COMMENTS

The ARB research program aims to collaborate with institutions engaged in similar research activities and to leverage funding whenever possible. ARB is continuing this trend in the 2014-15 fiscal-years by committing \$1,000,000 over the next two years to support the creation of the NCST at UCD. This proposed project will partially fulfil the \$1,000,000 commitment and will leverage the \$5.6 million award the NCST received

from the U.S. Department of Transportation and \$4.6 million from State, regional and local agencies, such as Caltrans and the South Coast Air Quality Management District.

The 10-person review team for this project included staff from the Stationary Source Division, the Air Quality, Planning and Science Division, the Mobile Source Control Division, and the Research Division at ARB. Staff wrote the original statement of work (SOW) based on the research needed to support the implementation of novel hydrogen pathways for the LCFS. However, the data will also be beneficial to staff working on the Vision Project and the Sustainable Freight Strategy. The director of the National Center for Sustainable Transportation forwarded ARB's SOW to researchers involved with the Center. After discussing the project with multiple researchers, ARB and UCD staff determined that the team lead by Marshall Miller at UCD and Arun Raju at UCR, were the ideal principal investigators for the project. ARB staff submitted a list of comments after receiving the draft proposal from the research team. The comments, which were addressed in the final research proposal, were primarily related to how and when the UC research team would interact with ARB staff to ensure that the same metrics and models were being used by both entities.

The UC research teams are well suited to effectively complete the tasks outlined in the proposal. The literature review, life cycle analysis, and hydrogen market assessment will +be completed by the UCD team. The technology and economic assessments will be completed by the UCR team. This division of labor leverages UCD's expertise in hydrogen LCA analysis and UCR's connections with industry for practical assessments of hydrogen technology and economic potential.

IV. STAFF RECOMMENDATION

Staff recommends the Research Screening Committee approve this proposal for a total amount not to exceed \$250,000, subject to inclusion of any changes and additions specified by the Committee.